The drawings stand objected to in paragraph 1 of the Office Action. It is respectfully submitted that the changes to the specification herein address and overcome any potential issue in this respect. All reference signs are now believed to be mentioned in the specification.

Minor Specification Typos Corrected

The specification has been amended to correct certain minor typographical errors. For example, in Table 1, SnO_3 has been changed to SnO_2. It is clear that this was a typographical error, as evidenced by the SnO_2 mentioned in the application as filed (e.g., pg. 9, line 15; and Table 3, Co. Ex. 4). The shifting of "Average 150" over one box in Table 1 for Co. Ex. 1 is supported by the instant specification as filed at pg. 24, lines 19-29. With respect to Table 3, the change of "10-200" to "20-200" for Ex. 7 is supported by the instant specification at pg. 36, lines 24-27; and the shifting of "Average 100" over one box with respect to Co. Ex. 4 is supported by the instant specification at pg. 38, lines 20-26. In comparative examples 1 and 4, tin oxide is clearly used; shapes of irregularities of these examples may not be included in certain embodiments of this invention, but material(s) of such irregularities (tin oxide) is included within the scope of certain embodiments of this invention.

Section 112 Rejection

Claims 3, 4 and 9-22 stand rejection under 35 U.S.C. Section 112, second paragraph, in paragraph 3 of the Office Action. It is respectfully submitted that the changes to these claims herein address and overcome any potential issue in this respect.

General

For purposes of example, and without limitation, certain example embodiments of this invention relate to a solar cell including a transparent conductive layer(s) which includes a plurality of holes at its surface on the side of the photoelectric conversion layer, wherein respective surfaces of the holes have irregularities defined therein. For example, the Fig. 1 embodiment of the instant application includes a glass plate 11a which supports a zinc oxide inclusive transparent conductive layer 11b. The transparent conductive layer 11b is etched so as to define a plurality of holes in a surface thereof. An example hole is shown in Fig. 2, where the hole has a depth 21 and a diameter 22. Irregularities of size 23 and pitch 24 are defined on a surface of the hole. In certain example embodiments, the diameter 22 of each hole is in the range of from 200 to 2,000 nm, the depth 21 of each hole is from 50 to 1,200 nm, and the difference in height 23 between each irregularity formed on the hole surface is from 10 to 300 nm (e.g., pg. 10, lines 21-25). In certain embodiments, the ratio of height difference 23 to space/pitch 24 is from 0.05 to 3, more preferably from 0.1 to 2 (e.g., pg. 10, lines 25-29). *Moreover, the holes are provided on the surface of the transparent conductive layer in an amount (i.e., number density) of from 0.5 to 2 holes per micro square meter (e.g., pg. 9, line 7); this density of holes on the surface surprisingly allowing unexpectedly improved results to be achieved as evidenced by Tables 2 and 4 of the instant specification (in Tables 2 and 4, compare embodiments of this invention within this range with Comparative Examples 3 and 8 which had a hole number density outside of this range, in particular 0.3 μm^{-2}).* The Fig. 4 embodiment differs from the Fig. 1 embodiment in that in Fig. 4 the substrate 11a

is etched so that holes and irregularities are formed on the surface thereof (e.g., pg. 22, line 27 to pg. 23, line 24).

Claim 1

Claim 1 stands rejected under 35 U.S.C. Section 102 as being allegedly anticipated by Wada (US 2002/0050289) and JP '530. This Section 102(e) rejection is respectfully traversed for at least the following reasons.

Claim 1 requires that "the transparent conductive layer is provided with a plurality of holes at its surface of the side of the photoelectric conversion layer, each of said holes having irregularities formed on its surface, and wherein the holes are provided on the surface of the transparent conductive layer in an amount of from 0.5 to 2 holes per micro square meter." For example, and without limitation, referring to Fig. 1 of the instant application, from 0.5 to 2 holes per micro square meter are provided in the surface of the transparent conductive layer 11b (e.g., pg. 9, line 7).

As explained above, it has surprisingly been found that a number density of holes within this claimed range (i.e., 0.5 to 2) leads to unexpected results. In particular, Tables 2 and 4 of the instant specification compare certain embodiments of this invention having a hole density within this range (e.g., Examples 1-10) with certain Comparative Examples having hole number densities outside of this range (e.g., Comparative Examples 3 and 8 had a hole number density outside of this range, in particular 0.3 μm^{-2}). It can be seen in Tables 2 and 4 that the Examples 1-10 which had a hole number density within this claimed range achieved much better results (e.g., better photoelectric

conversion efficiency) than did the Comparative Examples 3 and 8 which had hole number densities outside of this claimed range.

Wada (note common inventor Wada with the instant application) and JP '530 both fail to disclose or suggest a hole number density of from 0.5 to 2 holes per micro square meter as required by claim 1. Thus, especially given the unexpected results described above associated with this claimed range, it is respectfully submitted that claim 1 patentably defines over both Wada and JP '530 in this respect. It is respectfully submitted that claim 11 defines over Wada for at least this same reason.

Claims 7 and 19

Claims 7 and 19 require that the ratio I_{220}/I_{111} of the integral intensity of (220) X-ray diffraction to the integral intensity of (111) X-ray diffraction of the i-layer is ***5 or more***. Both Wada and JP '530 fail to disclose or suggest this aspect of claims 7 and 19. The ratios discussed in Wada are well less than this claimed "5 or more" range. Furthermore, this claimed range is clearly not inherent in JP '530 as alleged in the Office Action, as evidenced by the much lower values disclosed in Wada.

Obviousness-type Double Patenting

Finally, the obviousness-type double patenting rejection over Wada is respectfully traversed for the reasons discussed above. In particular, Wada fails to disclose or suggest the claimed hole number density of from 0.5 to 2 holes per micro square meter. Moreover, in view of the unexpected results associated with the same, this is not merely an obvious modification.

For at least the foregoing reasons, it is respectfully requested that all rejections be withdrawn. All claims are in condition for allowance. If any minor matter remains to be resolved, the Examiner is invited to telephone the undersigned with regard to the same.

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: ______________________
Joseph A. Rhoa
Reg. No. 37,515

JAR:caj
1100 North Glebe Road, 8th Floor
Arlington, VA 22201-4714
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

#8
attach

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

The Table 1 beginning at page 29, line 3:

Table 1

	Etching Time (sec.) Other Forming Condition	Surface Shape of Second Transparent Conductive Layer				I_{220}/I_{111} *
		Hole Diameter (nm)	Hole Depth (nm)	Irregularity Size on Hole (nm)	Irregularity Size on other than Hole (nm)	
Ex 1	180	200-1400	80 – 1000	10 – 280 Average 120	<10	3
Ex 2	240	400-1000	100 – 700	20 – 200 Average 150	20 – 40	3
Ex 3	240	400-1000	100 – 700	20 – 200 Average 150	20 – 40	5.5
Ex 4	180 ZnO / ZnO	200-1400	80 – 1000	20 – 280 Average 130	20 – 50	3
Ex 5	--	400-1000	100 – 700	30 – 120 Average 80	30 –120	3
Co Ex 1	ZnO /SnO[3]2	--	--	[Average 150]	[--]Average 150	1.5
Co Ex 2	60	50-200	10 – 100	<10	<10	3
Co Ex 3	--	800-3000	700-2000	150 – 500 Average 350	150 – 500	1.4

* : Orientation of crystalline silicon photoelectric conversion layer

The paragraph beginning at page 32, line 7:

A multi-junction type thin-film solar cell of a super-straight type in this Example has substantially the same structure as that shown in Fig. 5. This thin-film solar cell has a substrate for a thin-film solar cell comprising a glass plate and a first transparent conductive layer formed thereon. Formed on this substrate are an amorphous silicon photoelectric conversion layer 27, second transparent conductive layer 11c, crystalline silicon photoelectric conversion layer 37, back surface reflecting layer 15 and back surface electrode 16 in this order. Formed on each surface of the first and second transparent conductive layers are a great number of holes each having approximately a sphere shape and reaching not to the glass plate 11a like the Example 1. The amorphous silicon photoelectric conversion layer 27 is made of a p-type amorphous silicon layer 12a, i-type amorphous silicon layer 13a and n-type amorphous silicon layer 14a, and the crystalline silicon photoelectric conversion layer 37 is made of a p-type crystalline silicon layer 12b, i-type crystalline silicon layer 13b and n-type crystalline silicon layer 14b.

The Table 3 beginning at page 43, line 5:

Table 3

	Etching Time (sec.) Other Forming Condition	Surface Shape of Second Transparent Conductive Layer				I_{220}/I_{111} *
		Hole diameter (nm)	Hole Depth (nm)	Irregularity Size on Hole (nm)	Irregularity Size on other than Hole(nm)	

Ex 6	200	200-1400	80 – 1000	10 – 280 Average 120	<10	3
Ex 7	280	400-1400	100 – 700	[10]20 – 200 Average 150	20 – 40	3
Ex 8	280	400-1400	100 – 700	10 – 200 Average 150	20 – 40	5.5
Ex 9	200 ZnO/ ZnO	200-1400	80 – 1000	20 – 280 Average 130	20 – 50	3
Ex 10	--	400-1000	100 – 700	30 – 120 Average 80	30 – 120	3
Co Ex 4	ZnO/ SnO_2		--	[Average 100]	Average 100	1.5
Co Ex 5	80	50-200	10 – 100	<10	<10	3
Co Ex 6	200 i- layer** 100nm	200-1400	80 – 1000	10 – 280 Average 120	<10	3
Co Ex 7	200 i- layer** 500nm	200-1400	80 – 1000	10 – 280 Average 100	<10	3
Co Ex 8	--	800-3000	700-2000	150 – 500 Average 350	150 – 500	1.4

* : Orientation of crystalline silicon photoelectric conversion layer
** i-layer : i-type amorphous silicon layer

IN THE CLAIMS

1. (Amended) A thin-film solar cell comprising:

a [set of a]transparent conductive layer and a photoelectric conversion layer laminated in this order on a substrate,

wherein the photoelectric conversion layer [is made of]comprises a p-i-n junction, and an i-layer [constituting]of the p-i-n junction is made of a crystalline layer, [and]

the transparent conductive layer is provided with a plurality of holes at its surface of the side of the photoelectric conversion layer, each of said holes having irregularities formed on its surface[.], and

wherein the holes are provided on the surface of the transparent conductive layer in an amount of from 0.5 to 2 holes per micro square meter.

2. (Unamended) A thin-film solar cell claimed in claim 1, wherein a plurality of holes are formed on the surface of the substrate, each of said holes having irregularities formed on its surface.

3. (Amended) A thin-film solar cell claimed in claim 1, wherein a diameter of each hole formed on the surface of the transparent conductive layer is in the range of 200 nm to 2000 nm, the depth of each hole is in the range of 50 nm to 1200 nm and a difference in height between each irregularity formed on the surface of the respective hole is in the range of 10 nm to 300 nm.

4. (Amended) A thin-film solar cell claimed in claim 1, wherein additional irregularities are formed on the surface [other than]of the transparent conductive layer in areas between the holes of the transparent conductive layer[on which the holes are provided], and a difference in height between each [irregularity]of said additional irregularities formed between the holes is in the range of 10 nm to 300 nm.

5. (Unamended) A thin-film solar cell claimed in claim 1, wherein the transparent conductive layer is made mainly of zinc oxide.

6. (Unamended) A thin-film solar cell claimed in claim 1, wherein the i-layer constituting the photoelectric conversion layer includes silicon or silicon alloy.

7. (Unamended) A thin-film solar cell claimed in claim 1, wherein the ratio I_{220}/I_{111} of the integral intensity of (220) X-ray diffraction to the integral intensity of (111) X-ray diffraction of the i-layer is 5 or more.

8. (Unamended) A thin-film solar cell claimed in claim 1, wherein the transparent conductive layer is oriented with respect to the substrate surface.

9. (Amended) A method of manufacturing the [for manufacturing a]thin-film solar cell of claim 1, characterized in that a surface of [a]the substrate and/or [a]the [first]

transparent conductive layer is etched for forming [a]said plurality of holes on the surface of the [first]transparent conductive layer [upon manufacturing a thin-film solar cell claimed in Claim 1]at the side of the photoelectric conversion layer.

10. (Amended) A method [for]of manufacturing [a]the thin-film solar cell of claim 1, characterized in that [a first]the transparent conductive layer is formed so as to have the plurality of holes on its surface, whereby [a]said plurality of holes are provided on the surface of the [first]transparent conductive layer [upon manufacturing a thin-film solar cell claimed in Claim 1]at the side of the photoelectric conversion layer.

11. (Amended) A thin-film solar cell comprising:

two or more sets of a transparent conductive layer and a photoelectric conversion layer laminated in this order on a substrate,

wherein a plurality of holes are provided on a surface at a side of a first photoelectric conversion layer of a first transparent conductive layer that is the closest layer to the substrate as well as on a surface at a side of a second photoelectric conversion layer of a second transparent conductive layer formed on the first transparent conductive layer, each of said holes having irregularities formed on its surface,

the photoelectric conversion layers each [is made of]comprise a p-i-n junction, and an i-layer [constituting]of the p-i-n junction of the first photoelectric conversion layer is made of an amorphous or a crystalline layer and the i-layer of each of the other photoelectric conversion layers is made of a crystalline layer[.], and

wherein, for at least one of the first and second conductive layers, the holes are provided on the surface of the transparent conductive layer in an amount of from 0.5 to 2 holes per micro square meter.

12. (Unamended) A thin-film solar cell claimed in claim 11, wherein a plurality of holes are formed on the surface of the substrate, each of said holes having irregularities formed on its surface.

13. (Amended) A thin-film solar cell claimed in Claim 11, wherein a diameter of each hole formed on the surface of the first and second transparent conductive layer is in the range of 200 nm to 2000 nm, the depth of each hole is in the range of 50 nm to 1200 nm and a difference in height between each irregularity formed on the surface of the respective hole is in the range of 10 nm to 300 nm.

14. (Unamended) A thin-film solar cell claimed in claim 11, wherein a difference in height between each irregularity formed on the surface of each hole provided on the surface of the second transparent conductive layer is smaller that that formed on the surface of each hole provided on the surface of the first transparent conductive layer.

15. (Amended) A thin-film solar cell claimed in claim 11, wherein additional irregularities are formed on the surface [other than]of the second transparent conductive layer between the holes of the second transparent conductive layer[on which the holes

are provided], and a difference in height between each [irregularity]of the additional irregularities formed on the surface of the second transparent conductive layer between the holes therein is in the range of 10 nm to 300 nm.

16. (Amended) A thin-film solar cell claimed in claim 11, wherein at least one of the transparent conductive layers is made mainly of zinc oxide.

17. (Amended) A thin-film solar cell claimed in claim 11, wherein the thickness of the photoelectric conversion layer including the amorphous i-layer is [first]one to four times as large as the average height difference between each irregularity formed on the surface of each hole provided on the first transparent conductive layer.

18. (Amended) A thin-film solar cell claimed in claim 11, wherein the i-layer [constituting]of at least one of the photoelectric conversion layers includes silicon or silicon alloy.

19. (Amended) A thin-film solar cell claimed in claim 11, wherein the ratio I_{220}/I_{111} of the integral intensity of (220) X-ray diffraction to the integral intensity of (111) X-ray diffraction of at least one of the crystalline i-layers is 5 or more.

20. (Unamended) A thin-film solar cell claimed in claim 11, wherein the first transparent conductive layer is oriented with respect to the substrate surface.

21. (Amended) A method [for]of manufacturing [a]the thin-film solar cell of claim 11, characterized in that a surface of at least one of the substrate, the [and/or a]first transparent conductive layer [and/or a]and the second transparent conductive layer is etched for forming [a]said plurality of holes on the surface of the first transparent conductive layer and on the surface of a second transparent conductive layer[upon manufacturing a thin-film solar cell claimed in Claim 11].

22. (Amended) A method [for]of manufacturing [a]the thin-film solar cell of claim 11, characterized in that [a]the first transparent conductive layer and/or [a]the second transparent conductive layer is formed so as to have a plurality of holes on its surface, whereby [a]said plurality of holes are provided on the surface of the first transparent conductive layer and on the surface of [a]the second transparent conductive layer[upon manufacturing a thin-film solar cell claimed in Claim 11].